

## OBSERVATIONS ON TUBERCULOUS ABSCESS OF THE CHEST WALL \*

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I have in mind, in presenting observations on tuberculosis of the thoracic wall, discussing some of the phases of the delicate balance between infection and resistance presented by local extrapulmonary foci of tuberculosis.

I approach the subject from the standpoint of one whose experience has been gained from observing and treating local tuberculosis of many of the different tissues and anatomical systems and not from the point of view of one who has devoted himself exclusively to the treatment of one anatomical system.

It has come about today that the treatment of tuberculosis of bones and joints falls largely to the orthopedic surgeon, tuberculosis of the genito-urinary tract to the genito-urinary surgeon, tuberculosis of the ovaries and tubes to the gynecologist, tuberculosis of pleura and lungs to the physician and those giving special attention to thoracic surgery, tuberculosis of the eye to the ophthalmologist, of the skin to the dermatologist. Tuberculosis of the gastro-intestinal tract and peritoneum and tuberculosis of the lymph glands fall to the general surgeon.

There is an obvious advantage in this surgical specialization, especially from the side of technique; suitable instruments are devised for diagnostic purposes adapted to the various regions under inspection; greater familiarity with normal and morbid anatomy of a given region is attained, from dealing with a considerable number of lesions of a given anatomical region. Operations are thought out and executed with greater skill than could be obtained by one treating but occasionally, similar condi-

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tions. I cannot help feeling however that there is a certain advantage in seeing and being familiar with the various manifestations of a specific generalized infection and of seeing the modification of the lesions caused by the same infecting agent brought about by the texture of the different tissues and the structure of the different anatomical regions. It is an advantage to be able to study the succession of lesions in different parts of the body and to have brought to one's attention the relation of the lesions to one another and to the phases of infection and resistance.

Tuberculous abscesses of the thoracic wall are not common. Few have the opportunity of reporting a large series of cases and yet they are sufficiently common for almost every physician or surgeon to see several instances. My own experience is derived from 18 cases that have come under my observation. The lesions have all been in adults, eleven men, seven women. Five were of the negro race. Three were over fifty-five years old.

I have been interested in these lesions because of their indolent course, their tendency to persist after excision, and by the fact that the foci occur in a region in continuous movement, every respiratory effort altering to some extent the position of the wall of the abscess or fistula. Their association with other lesions and the controversies over the site of the distributing focus and the differences of opinion expressed as to the method of treatment and the excellent results following the radical removal of the foci, have all arrested my attention.

The disease, as Koenig<sup>1</sup> expresses it, begins for the patient and the physician with the recognition of a swelling. This swelling progresses slowly with little or no pain. It is hemispherical when situated over the sternum or sternoclavicular joint, and oval with the long axis parallel with the rib when situated on the lateral chest wall. Sooner or later the swelling softens and breaks through the skin or is incised by a physician, leaving a fistulous tract. The orifice of the fistula may heal and then a new opening forms at some distance from the first; gradually complicated fist-

ulous tracts develop so that considerable areas of thoracic wall are undermined and openings are found far from the original focus. At first there is little disturbance of health, the body temperature is usually hardly altered. In other words the disease presents itself as a painless tumor or as an intractable fistulous tract which annoys the patient by the necessity of using a small dressing to take up the discharge.

I have followed the teaching of Watson Cheyne<sup>2</sup> and Koenig<sup>7</sup> and other surgeons of thirty or more years ago and have attempted to remove the entire local focus of infection. The anatomy of the region makes it possible to carry out a radical removal of the diseased area without undue difficulty and without mutilation.

If there is an unopen tuberculous abscess, the attempt is made to remove it by a sharp dissection. It will usually be found passing to a rib or a costal cartilage, the junction of rib and cartilage or a portion of the sternum, or the sternoclavicular joint. These structures are carefully removed with the sac.

The rib is removed well beyond the area involved and the costal cartilage when involved is completely removed, dividing the rib just beyond the costo-chondral junction and removing the costo-sternal junction completely. At times the tuberculous sac leads to an intercostal space, a small point or several points of granulation mark the spot where the tuberculous process has found its way into the cellular tissue of the thoracic wall. If a probe be passed along this granulating tract it will be found leading beneath one of the ribs or rib cartilages and a removal of this rib or cartilage exposes a secondary abscess. Although the walls of the sac removed show tuberculosis, occasionally neither the rib nor cartilage show any tuberculous infection. The deep wall of the cavity after the rib is removed is made up of the endothoracic fascia and the pleura. When the granulation tissue is removed from the endothoracic fascia, I have in no instance found a defect leading to a focus in the pleura nor have I removed tissue that had the appearance of a lymphatic gland.

When fistulae are present I have attempted to remove them in much the same way, carrying the dissection into the sound tissue about the fistulous tract, circumscribing the orifice and following the tract to its origin. In most of the patients with fistulae, one or more operations had already been performed, usually incision, curettage and packing. These fistulae have often been very extensive and complicated, in one instance reaching from the fifth rib nearly to the crest of the ileum with numerous side canals. In one patient the fistulous tract led to an opening in the pleura and on removing several ribs and the underlying wall a considerable cavity was exposed. A section of the wall showed a thickened tuberculous pleura. The patient had had a tuberculous empyema which had been opened without recognizing the nature of the condition.

When in the course of dissection it has been necessary to remove portions of the costal cartilage there has been a tendency for the cut end of the cartilage to become infected and the fistula to persist, not from the original focus but from one created by the operation undertaken for its cure.

This tendency of the severed costal cartilage to become infected has been noticed by a number of surgeons and has led to the practice of removing the entire costal cartilage.

If the process involves one of the lower ribs, carrying out this principle may make necessary an extensive operation. In one instance in which the focus was in the sixth costal cartilage, permanent healing did not take place until the entire plate of cartilage, made up of 6, 7, 8 and 9th costal cartilages, with corresponding portions of ribs was removed. I have closed the skin with interrupted sutures without drainage after painstaking hemostasis. It is well known that secondary infection is prone to find its way along material introduced for drainage.

From findings at operation it is evident that the rib, costal cartilage, sternum, the sterno-clavicular joint, the pleura and possibly the subcutaneous tissue may all be sites of a local tuberculosis.

It has been contended, especially by French writers on this subject, that tuberculous abscesses occur unrelated to an involvement of the bone, cartilage or lymph glands. They are spoken of as tuberculous gummata. They are described as appearing as small tumors in the subcutaneous tissue, at first not adherent to the derma and independent of the deeper tissues. They soften and break down producing a typical cold abscess. As they increase in size they invade neighboring structures, by extension of the tuberculous process.

Tubercle bacilli seem to lodge and grow in synovial membranes, in bones, lymph glands, bursae and synovial sheaths of tendons and not usually in the subcutaneous cellular tissues. In seeing a cold abscess one immediately thinks of a focus in one of these structures. I have never seen an isolated subcutaneous focus unrelated to these structures.

It has further been advanced and demonstrated that certain of the abscesses have their origin in the pleura. A number of autopsy reports and careful observations were presented by Souligoux<sup>3</sup> in his Paris Thesis, forty years ago. He showed lymphatic vessels of adherent pleura communicating with those of the intercostal space. Normally little developed and incapable of being injected with mercury they are, on the contrary, large and easily injected in cases of inflammation and adhesion of the pleura, making a communication between lymphatics of the lungs and those of the intercostal space.

Robinson<sup>4</sup>, in the reports of the Mayo Clinic, in 1917, basing his conclusion evidently on evidence presented by Souligoux and the negative findings in the ribs in patients he had treated, assumed that the abscesses were usually pleural in origin. Auchincloss<sup>5</sup> showed before the New York Surgical Society, twelve years ago, a patient on whom he had operated for a thoracic abscess. After removing the fifth and sixth ribs and the intercostal muscles he exposed a sinus about a half centimeter in diameter which led to a sheet of calcified tissue. He dissected out at a second operation, this sheet. It lay over the lower part of the

lung, the diaphragm and the outer part of the pericardium. Evidently tuberculous infection of the pleura is the source of the cold abscess in some instances.

I surmise that in the limited number of instances that come under any one surgeon's observation, different conclusions may be drawn as to the site of the focus of infection. Sayag<sup>6</sup>, in his thesis on the study of cold abscess of the thoracic wall reported forty-five cases, thirty-eight were children and seven adults. In thirty-one there was a lesion of the ribs or costal cartilage alone without any lesion of the pleura. In seven there was a cold abscess of the soft parts without any lesion of the ribs or pleura. Pleural lesions were connected with the thoracic abscess three times in forty-five cases.

Koenig<sup>7</sup> in his article on tuberculosis of the chest wall found the usual focus in the ribs, costal cartilage or sternum. At times the focus was subperiosteal, at times in the medullary substance and at times in the perichondrium or at the junction of the rib with the cartilage. He shows six figures of different forms of lesions of the periosteum or bone that had come under his observation. Only once had he seen invasion of the rib from a focus in the pleura. In my series, the pleura was the infective focus in one of the eighteen cases. In this instance it was rather a tuberculous pleurisy than the condition described by Souligoux.

In the great majority of cases the infection must therefore reach the rib, the sternum, the sterno-clavicular joint or possibly the soft parts or the cartilage by the blood stream, not by spread through the lymphatics from the lungs. This is borne out by metastatic lesions, preceding, following or occurring at the same time as the thoracic lesion. Tuberculosis of the malar bone, the gluteal bursa, the ankle joint, the testicles, the knee joint, the lymph glands have occurred in various combinations with the thoracic lesions, in the patients I have observed.

The x-ray findings of the lung showed in three cases of the eighteen, evidence of active pulmonary lesions. In others the x-ray examination or the physical examination

showed no lesions in the lungs or only signs which might be interpreted as healed lesions. x-ray examination of the chest wall in no instance showed the lesion in rib, cartilage or sternum. The superficial process in the bone evidently does not reach a size sufficient to be recognized before it has set up an abscess easily appreciated in the chest wall.

The results of local removal of the tuberculous process has resulted in local cure in twelve, in six a sinus persisted. Of the twelve patients locally healed, in one there is still evidence of a lung lesion. This patient has gained twenty-five pounds and the lesion in the lung is apparently commencing to cicatrize. The patient with a very complicated and extensive fistulous tract when seen last, nineteen years after his operation was hale and hearty and eighty-two years old. The patient in whom it was necessary to remove the entire mass of the sixth, seventh, eighth, and ninth costal cartilages, and considerable portions of the adjacent ribs, is alive and well at seventy-four, fourteen years after operation. Seven have been seen two, four, six, nine and fourteen years after operation. I have been unable to follow six of the patients. One was well two years after operation, one returned to Italy with a sinus still present. Two died within two years of their operations from tuberculosis. Nine have had multiple operations. All have been kept under observation for a year and as a second focus was appreciated it was excised. There has been a pronounced gain in weight and in general health following the excision of the foci and final healing.

One year ago a patient came under my observation who illustrates so well features to which I wish to call attention that I will report the case in some detail. A vigorous negro was admitted to my service in St. Luke's Hospital complaining of a lump over the right upper portion of the chest. He had no pain, the mass was not tender, there was no pain on moving his arm. His past history was negative except for a swelling on his cheek which had disappeared spontaneously. X-ray was negative except for diffuse haziness overlying the upper portion of the left chest. There was no evidence of a lung lesion. The mass over the upper

left chest was hemispheric, soft, fluctuating, the size of a large cocoanut. The swelling was aspirated and one thousand cubic centimeters of thin white pus withdrawn. A guinea pig inoculated with some of this material showed lesions which yielded acid fast bacilli. Several of the surgeons who saw the patient advised that the abscess be repeatedly aspirated and that he be transferred to Sea View Hospital for open air treatment. The point of view expressed was that experience has shown that it was undesirable to incise a tuberculous abscess, that the walls regularly became secondarily infected, that tuberculosis with secondary infection progresses more rapidly and rarely heals. The patient, they said, would be given a better chance to overcome the infection by suitable climate, fresh air and sunshine. I dissented from this opinion and advised that the abscess wall be excised and the focus in the sternum or rib removed and that he then should be given the treatment suggested. The operation was performed by Dr. Heeks of my staff. An incision was made down to the wall of the cavity. The contents of the cavity were aspirated and as much of the wall as possible excised by sharp dissection. The first rib was disarticulated from the sternum and its medial third excised, the clavicle disarticulated from the sternum and its medial third excised. The portion of manubrium adjacent to the articulation was removed. The severed muscle fibres of the pectoral were brought together by sutures and the skin wound carefully sutured. A small rubber dam drain was inserted near the angle of the wound.

Microscopical section of the tissue removed showed the bony fragments widely involved with tuberculous granulations, the tuberculous tissue extending as far as the cartilaginous covering of the articulation. There were a number of large tubercles with typical Langhans giant cells and a small amount of cheesy degeneration. The day after operation the evening temperature was 101.2. This temperature gradually subsided and was normal on the sixth day. He left the hospital on the fifteenth day with the wound healed except for a small sinus at the site of the cigarette drain.



He was sent to the country and told to rest and keep in the open air as much as possible. He returned four months later, apparently in excellent health, the wound healed except for persistence of a small sinus but a swelling had appeared over the left malar bone. It was painless, not tender and fluctuating. The skin over it moved normally. He was advised to have a second operation.

The skin was dissected from the swelling, the abscess opened. The pus was beneath the periosteum, there was a distinct punched out area measuring about one centimeter, in the underlying bone. The adjacent tissue was cheesy and easily removed with a curette, the tuberculous periosteum and the wall of the cavity were excised and the wound closed without drainage. The wound healed by first intention. The patient was again sent away. He returned after a month with both wounds soundly healed and begging that he might be permitted to return to work. When seen several weeks ago he was well and earning his living.

In this instance there was no evidence of secondary invasion of the bone by extension from the pleura. The infection must have reached the bone by the blood stream. The lesion in the malar bone is further evidence of metastasis. Why did this, to all appearance, healthy man present a large tuberculous abscess without appreciable constitutional symptoms? Why did he heal so promptly when the local lesion was excised? What are his chances of later developing chronic tuberculosis of the lung? Why should he have had a second lesion in the malar bone?

The answers to these questions bring up the whole question of the phases of tuberculous infection and superinfection.

I believe it of some value to surgeons to take cognizance of the ideas that are being developed regarding the sequence of lesions in tuberculosis, even if the views held are tentative, and obviously subject to revision.

In the sixth edition of Bruns' Handbook of Surgery, published in 1931, in the chapter on the surgery of the chest,

Professor Herrmannsdorfer writes, "Tuberculous inflammation attacks the chest wall itself. In the secondary stage (Ranke) the inciting agents gain entrance to the blood stream and are deposited in the ribs, sternum or soft parts." In publications on various aspects of infection with tubercle bacilli, one is beginning to see the terms primary, secondary and tertiary tuberculosis used.

Ranke<sup>7</sup> expressed his views in a lecture delivered in Munich in 1917. He said that his aim had been to find some law expressing the relation between the manifold manifestations of tuberculosis and to explain their sequence with reference to the laws governing the course of the various infections. He had reached his conclusions after many years of pondering on clinical observations and pathological examinations.

The tubercle bacillus and its toxins were typical antigens and the stages from the appearance of primary lesion to the late manifestations were the expressions of the reacting organism modified by a gradually increasing immunity.

The primary effects had already been studied and demonstrated by Kuss and later by Albrecht and Ghon, and Hamburger from clinical observations had already suggested this division into stages.

The primary stage gives a characteristic anatomical picture. It is seen usually in childhood and youth. It is confined to a small area in the lung, the neighboring lymphatics and lymph glands. It is limited to these structures and the involvement of the lymph glands is retrograde. Not only has this primary lesion a characteristic histological structure, but it heals in a characteristic manner so that one familiar with the lesion should be able to tell from the healed scar its primary nature.

When the primary lesion does not heal, a secondary stage sets in. It is characterized by widespread dissemination by the lymphatics, by the blood stream, by spread on serous and mucous surfaces and by progression by contact growth. The lesions are characterized by rapid exudation and case-

ation, at the same time highly increased sensitiveness to the toxins of the bacilli is developed.

Gradually this reaction to the toxins diminishes and a gradual development of immunity sets in. There is a regression of lymph and blood stream metastases and a retrogression of the perifocal exudative inflammation. The regional lymph glands become gradually smaller in relation with the volume of the organs to which they belong and finally almost completely disappear. Further, metastases by the blood and lymph stream no longer occur but contact invasion and spread in an infected organ may continue.

The tubercle bacilli which have been transported and deposited in the lymph glands lose in this stage their capacity for multiplication and for the production of toxins, the bacilli are much changed if not actually dead. In any event they are rendered harmless.

At the end of the stage of generalization a stage follows marked by humoral immunity and a relative insensitiveness to the toxin. Local disease, shut off largely from the blood and lymph, exists and may progress.

There is much evidence which confirms these views of Ranke. Aschoff<sup>8</sup> writes that the histological characteristics of the primary lesion and the appearance of the healed primary lesions have been generally accepted by the scientific world.

That there is a period of dissemination seen often in childhood, is obvious to all who have had the opportunity to study and observe in infancy the widespread glandular involvement, the appearance of multiple lesions, the rapid invasion and spread of local lesions.

That there is a third stage in which local more or less shut in or encapsulated foci appear which yet progress locally by extension without glandular involvement and with a very chronic course, is also obvious.

The proof that some such sequence is followed is furnished by observations made on adults who have not lived

under conditions where they were exposed to tuberculosis in infancy and childhood and in whom the primary complex and the secondary anaphylactic phase can be studied and followed. Thus Aschoff<sup>8</sup> writes, "I have observed most serious cases of infection in a very large number of autopsies of Anatolian peasants, who came from mountain villages and in whom it was impossible to find any trace of previous phthisis. Here we found pictures like those usually seen in childhood during the stage of generalization." Borrel<sup>9</sup> in studying tuberculosis in the Senegalese troops in the French army, showed that it differs completely from the tuberculosis seen in adults in urban communities. The disease presented a very great analogy with the course of severe tuberculous infection in young children.

Borrel showed that only 4 per cent of the Senegalese soldiers gave a positive reaction to tuberculin. In those who did not react and had never been infected with tuberculosis the disease ran a severe course presenting two phases, one with no fever and few constitutional symptoms but with glandular involvement corresponding to the territory invaded, lasting two or three months, and a secondary stage characterized by fever and generalized lesions with caseation. The second stage was short and resulted fatally.

Inoculation experiments on animals have made clear that superinfections and the intervals of time between infection and superinfections as well as the dose and virulence of the organism profoundly alter this picture.

The classic experiment of Robert Koch<sup>10</sup> made in 1891 and which led to the discovery of tuberculin was the starting point of investigations that have elucidated the question of superinfection and the modifications in the course of the disease.

"If one inoculates a guinea pig with pure culture of bacilli the puncture heals normally. From the tenth to the fifteenth day there appears at the point of inoculation a hard nodule which soon opens and produces an ulcer which persists up to death. Guinea pigs already infected from

four to six weeks, then inoculated a second time behave very differently. A nodule does not form at the point of inoculation, but on the next day or the day after, the point of inoculation becomes hard, takes on a reddish violet color, then becomes blackish over an area of 0.5-1 centimeters. In a few days the skin becomes necrotic, sloughs away leaving a superficial ulcer which heals rapidly and definitely without involvement of the neighboring glands."

Thus tubercle bacilli act very differently when inoculated under the skin of a guinea pig already tubercular than when under the skin of a healthy animal. In animals heavily infected this phenomenon does not take place. A relatively small dose is then rapidly fatal.

During the last forty years this experiment has been repeated and confirmed. To produce the phenomenon however, the original dose must be small, just sufficient to produce a chronic disease and the second inoculation must be a minimal dose.

The condition under which children live, especially in urban communities, exposes them to contacts usually intermittent, and in small doses, initial invasion can take place without clinical manifestation and reinfection, or to speak properly, superinfection (for reinfection implies a complete recovery and destruction of the original invading parasite) may be delayed until some degree of immunity is established. Clinical tuberculosis occurs when the virulence, the size of the dose, or the timing of renewed infection breaks down the defense mechanism.

Tuberculosis then, as seen clinically presents a great variety of pictures due to the timing of the exogenous and endogenous superinfection, as well as the size of the initial dose, and virulence of bacilli. And generalization occurs in the non-sensitized body, the body more or less resistant, and the body highly resistant. Saenz<sup>11</sup> in the Bulletin of The Pasteur Institute in 1933 made a report on blood cultures in patients with tuberculosis. He had developed a special technique and was able to find 5.2 per cent positive cultures in 500 examinations. The positive findings were largely in

infants and were determined before the appearance of allergy and before the signs of tuberculosis recognizable by clinical methods. It has always seemed to me that as micro-organisms were mostly immobile an indication of their behavior when first introduced is given by the fate of particulate matter introduced into the circulation. It is well known that when minute particles of carbon are introduced into the ear veins of rabbits they disappear from the circulating blood and are found scattered throughout the body but are deposited especially in catch basins such as are furnished by the anatomical arrangements in the lymph glands, the bone marrow, the liver, and the spleen, where conditions are such that particles carried along in the circulating blood have a tendency to settle. The circulating bacilli are largely taken up and destroyed in these regions. In this destruction the tissue gradually acquires the property of hypersensitiveness. Where the bacilli are deposited in sufficient quantities they may overcome the local defense mechanism and start to grow. As they multiply they may again disseminate but this time in a sensitized body and where they lodge there is rapid swelling and destructive inflammation.

Hypersensitiveness may develop to such degree that it is itself a danger from the destructive progressive lesions produced, although high immunity exists. Further, local lesions may occasionally occur in the intima of a large vein or thoracic duct. If such a lesion breaks into the lumen of the vessel, necrotic fragments and multitudes of bacilli will be carried throughout the body at a time when considerable allergy has been established, thus producing the various forms of miliary tuberculosis.

The attempt to place tuberculosis of bone, joint, lymph glands and other forms of extrapulmonary tuberculosis in relation to these phases of infection is interesting. They belong to a group of lesions which for many years were called scrofulous and had characteristics which made it difficult for older clinicians, before the discovery of tubercle bacilli to consider them tuberculous. The lungs in many

instances were not involved, there was no evidence of pulmonary tuberculosis, or it appeared late in the disease and ran a very chronic course. Further, adults with chronic pulmonary tuberculosis rarely showed extrapulmonary lesions.

The law of Marfan quoted by Calmette<sup>12</sup> is also in agreement with the older clinical observations. "One almost never finds evidence of pulmonary tuberculosis in subjects who during infancy have been attacked with tuberculous adenitis and who have recovered completely before the age of fifteen, this recovery having taken place before any other focus of tuberculosis has been appreciated."

Evidently the usual forms of adult pulmonary tuberculosis are the result of exogenous superinfection of the lung. And when such a pulmonary lesion becomes established, sufficient immunity is produced to prevent the formation of extrapulmonary foci.

Conversely, when during the course of generalization, due to mass action of the bacilli, or locally diminished resistance, one or more local extrapulmonary foci develop, they have a tendency to establish enough immunity to prevent superinfection of the lung.

Further, the timing of superinfection in groups of lymph glands may set up such immunity that renewed infection in other parts of the body is extremely unlikely.

Thus the tuberculosis that the surgeon sees and treats is a form in which enough resistance has been established to make local lesions of considerable size and enough sensitiveness to make local destruction. He frequently sees patients with but a single lesion representing the end stage of a generalized infection in which the defense mechanism had destroyed the invading bacilli except where their mass action has been able to establish a foothold. He sees, not infrequently, multiple destructive foci with apparent high immunity. And he sees patients with slowly progressive local destructive lesions which slowly advance and gradually break down the defense mechanism. He is not called

on to treat the patient in whom the defense mechanism is so efficient that there is no clinical evidence of the bacterial invasion and he is not called on to treat overwhelming invasion or metastases in the early stages of generalization. His patient falls in the group where the forces of the invading bacillus and the forces of the invaded body are nearly equal or are largely on the side of the invaded, and the foci are accessible.

Many of the instances of bone and gland tuberculosis give evidence of frequently repeated inoculation with bacilli of low virulence. Thus Fraser<sup>13</sup> in studying a consecutive series of seventy cases found evidence of bovine bacillus in forty-one. The medium was milk and the manner of inoculation was by ingestion. It would seem likely that the patients who presented similar lesions and in whom the infection was due to the human bacillus may have been infected in the same way by bacilli of low virulence or in very small doses ingested by sucking soiled fingers and putting all manner of objects in the mouth in children growing up in a household where one or more members had an open tuberculous lesion.

In these instances the bacilli ingested passed through the sound intestinal mucosa. The tubercle bacillus is thus carried and distributed throughout the body without any lesion in the area of inoculation. Such a path of invasion has been repeatedly demonstrated. The mechanism of absorption and the path of invasion is presented by Calmette in his book on Tuberculosis. Moreover the animals examined showed no lesions in the mucosa. That is one of the observations that caused Calmette to deny the law of Cohnheim, a law that states that the point of invasion of pathogenic microorganisms is marked by definite lesions. An interesting confirmation of the absorption through the intestinal mucosa has been furnished recently by Saenz in the paper already referred to. Specimens of blood taken from infants cultured for the tubercle bacillus three to five hours after the ingestion of a dose of a nearly avirulent bovine bacillus (BCG) were positive in three out of four examined. Two chimpanzees were inoculated by ingestion of BCG. Four



hours later blood was withdrawn and cultured for tubercle bacilli. Positive cultures were obtained in each instance.

Similarly Park and Krumwiede<sup>14</sup> showed in children under five with cervical adenitis, the bovine bacillus in twenty-one instances and the human bacillus in fifteen, and in children from five to sixteen, in twenty-one the bovine and in thirty-six the human bacillus. Here again the significant fact seems to be that repeated inoculation by organisms of low virulence (bovine or human) introduced in a special way can set up lesions which are confined to the lymph glands and run a relatively benign course.

The comparison of tuberculosis with syphilis is broken by the effects of repeated small superinfection so timed that many of the patients never pass through any such sequence as is described by Ranke.

The comparison with glanders shows a far greater resemblance. Glanders as seen in man is a generalized and usually fatal disease and yet Dr. Hitzrot<sup>15</sup> showed before the New York Surgical Society twenty-three years ago a man on whom he had operated for a circumscribed osteomyelitis of the radius. Glanders bacilli were cultured from the pus of this abscess. The experiments on animals made by French veterinarians explain the occurrence. If Nocard<sup>16</sup> mixed with the feed and drink of horses small amounts of the culture of the bacilli, he was able to inoculate the animal so that chronic forms occurred with localized lesions. In autopsies on animals with this form of the disease the characteristic nodules were found in the lungs often with deposits of lime about them.

To repeat, the extrapulmonary metastatic lesions seen by the surgeon represent the results of dissemination in an organism which has established considerable resistance. Local circumscribed foci of infection represent a late manifestation of a general infection that has been largely overcome and where, although the balance between invading parasite and invaded host is still delicate, can readily be tipped in favor of the host.

The treatment of extrapulmonary tuberculosis or for that matter, the treatment of various forms of superinfection of the lungs spoken of as adult pulmonary tuberculosis bears this out. General resistance waxes and wanes with a variety of external conditions. Thus Borrel makes the astonishing statement that fifty per cent of the Senegalese soldiers infected with tubercle bacilli on virgin soil, taken out of the army and placed under suitable conditions with rest, sunshine, proper food, etc., recovered if their treatment was begun during the first stage when they were without fever and the only evidence of the disease was the enlargement of a group of glands.

In contrast the South African Tuberculosis Commission<sup>17</sup> investigating tuberculosis in negro workers in the gold mines found that although a large proportion of workers reacted to tuberculin they become severely infected with a form that resembled the tuberculosis seen by Borrel, except for differences in the initial lesions. Prof. Lyle Cummins, in commenting on this fact suggests that the condition under which the South African negroes live in their own community, with sunshine, fresh air, and suitable food was such that although they were inoculated, and although such inoculation was ample to protect them at home, it was not sufficient to protect them when exposed to fatigue, and work in dark warm air with repeated contacts.

The surgeon has at his disposal for treatment various measures aside from sunlight, nourishing food, rest and removal from contaminating contact. Puncture and aspiration, incision and incision with scraping, immobilization and excision, heliotherapy and x-ray seem capable of initiating healing such that a local focus no longer gives clinical evidence of its presence.

One of the most curious instances was brought out in the observation made by Spencer Wells seventy years ago. He was operating on what he supposed was an ovarian cyst. When the abdomen was opened a large amount of serous fluid escaped and scattered through the abdomen were seen massive tuberculous lesions. He closed the abdomen and to

his surprise the patient recovered and the signs of tuberculosis disappeared. I know of no more astonishing experience in the surgical treatment of infection than this inexplicable setting in of recovery in certain types of peritoneal tuberculosis after simple incision through the abdominal wall and allowing the serous exudate to escape. I have recently seen a well nourished middle aged woman twenty years after what seemed to be a hopeless massive infection of the peritoneum. The abdomen was soft, not distended and no masses were palpable.

It is probable that the irritation of the peritoneum by the operative interference, the change of temperature, the exposure to air and the temporary arrest of peristalsis that exists for some hours after a laparotomy may be sufficient to start recovery. In any event it is a startling example of slightly changed conditions in the local environment checking the growth of the bacilli and determining a favorable outcome.

It has long been known, however, that incision of a broken down tuberculous focus or the opening of a tuberculous abscess in the subcutaneous tissue is unsatisfactory and does not lead to cure. Except in small lesions the focus does not heal. For months and even years persistent fistulae exist, occasionally closing but again opening and discharging. The tuberculous lining of the abscess becomes secondarily infected by pyogenic organisms.

If the focus be in a gland or if it be small, after a time healing may occur. In other instances the infected patients slowly succumb to tuberculosis or die after prolonged supuration from amyloid degeneration of the viscera. The tissues behave much the same as when the opening of the abscess occurs spontaneously. That infection in the lymph glands will heal spontaneously, the broken down necrotic material being finally discharged, is attested by the observation of scars on the neck. These were formerly far more common. Professor Allbutt<sup>18</sup> writes, "In the sixties and seventies it was as common to see persons marked by the scars of scrofula as it still was to see the marks of the ravages of smallpox."

The treatment fifty years ago with poultices and iodine paint resulted, as Dr. Allbutt writes, in "a tedious illness, unwelcome disfigurement and possible dissemination." In local tuberculosis neither incision nor spontaneous opening causes satisfactory healing. With wide incision with scraping away the tuberculous granulation, more is accomplished, but the complete removal of the focus in bone or cartilage or lymph gland or a bursa shows that local deposits of tuberculous infection are not reached by the scraping instrument. The process continues much as in instances of spontaneous opening. Evidently, although the infection is limited and although there is a large degree of immunity the body is not materially aided by these mechanical measures and the same is true of repeated punctures.

Excision of a circumscribed tuberculous focus by sharp dissection, if the lesions are removed at the end of the period of dissemination, or still better when they represent residual foci with high general immunity give satisfactory results. The balance seems to turn sharply and definitely in favor of recovery. The soft parts frequently heal by primary union, or a small sinus persists which heals in a month or two. Moreover an impulse toward healing seems to be given to other lesions.

In tuberculous glands of the neck, when the disease is local and represents a focus at a stage when there is high general immunity and a destructive local lesion, the results of excision are admirable. When the large and obviously diseased glands are removed others in the chain, often smaller than a pea, probably escape removal, yet the neck heals soundly and the lesion in the other glands regresses. It has always seemed to me that the best results were obtained by the effort to remove, with as little traumatism as possible, the focus of infection, carrying the dissection if possible through sound tissues outside the focus but with the recognition that areas of surrounding infection would probably be left and in regions where a complicated and mutilating dissection might be necessary to limit the dissection to the obvious and main focus. A second operation

may be necessary later, but it has seemed to me the patient did better when extensive tuberculosis was treated in this way than when it was approached as if one were dealing with a carcinoma.

It is essential, however, to remove the main or distributing focus of infection. The extensions from this focus will frequently heal when the main focus is removed.

I have repeatedly seen a latent secondary focus in some other part of the body become active after excision. The negro with large thoracic abscess, gave a negative history except for a swelling over his malar bone which had disappeared spontaneously. When the abscess wall and sternoclavicular joint were removed although the patient continued in good health this secondary focus became active and a fluctuating mass appeared over the malar bone which was operated on four months later. A girl of thirteen was brought to me for amputation of the arm. She looked very ill. About the elbow joint and in the upper forearm were numerous pus discharging sinuses. The x-ray showed extensive destruction of the joint. A guinea pig inoculated from a fragment removed showed lesions of tuberculosis. x-ray of the skeleton showed an area in the tibia near the joint on the opposite side which suggested a second focus of infection. I refused to amputate but advised resection of the elbow-joint. The joint was resected, the soft parts finally healed and the sinus closed but the lesion in the knee became active and a third focus appeared in the wrist. In two instances I have seen this same lighting up of other foci after amputations for tuberculosis. All three of these patients notwithstanding the multiple foci, recovered. They are possibly examples of a highly developed hypersensitivity and high immunity.

One is repeatedly warned that resection and excision will be followed by dissemination and miliary tuberculosis. That miliary tuberculosis occurs in children with localized tuberculosis is generally recognized. How often does it occur after operation? Are tubercle bacilli disseminated by operations? The bacilli in a shut-in local focus are few

in number, the general immunity is considerable or the local lesion would not exist. It is unlikely that the bacilli disseminated by operations set up widespread lesions. Miliary tuberculosis results from the rupture of a tuberculous focus into the thoracic duct or into a vein. Millions of bacilli, toxins and necrotic material are distributed throughout the body. May not the operative interference activate such a local focus in a vein and cause its rupture, just as it activates the foci which can be readily appreciated? In 1905 Wittmer<sup>19</sup> collected 763 case reports of resections and secondary amputations. In this number there were twenty-four deaths from acute miliary tuberculosis following operations. The report covered a period when very extensive and mutilating resections were considered necessary and where the unfavorable outcome often resulted in secondary amputation. Wittmer writes that he has been unable to find a single instance after the excision of tuberculous glands.

The unsuspected presence of an intima tubercle in the vascular system is one of the menaces of generalized tuberculosis. That such a focus may be activated by an operation is possible but it may also be activated by the course of disease untreated. I know of no statistics which show the relative danger.

Excellent results have been obtained on the spine, in the knee and hip by various varieties of fusion operations without excision of the focus in the bone. The elimination of motion in the diseased joints, possibly by causing the slowing of the lymph flow and by removing the irritation of the frequent disturbance of the focus of infection turn the scale in favor of the invaded organism. In a series reported by Hibbs<sup>20</sup>, cure resulted in slightly over seventy per cent.

Hibbs writes, "It is interesting to find that in twenty-eight cases of tuberculosis of other joints occurring in conjunction with that of the spine, fifty-four per cent became quiescent following the spine fusion." Cure was said to take place when the fusion was solid and the general health good and there was no apparent activity of the disease.

Slightly over one per cent developed generalized tuberculosis within two months of the operation.

It is obvious then that in local tuberculosis simple immobilization not only initiates healing in the joint fused but has a beneficial effect on other foci of infection.

In local tuberculosis of the chest wall, immobilization is nearly impossible. Each breath must change the lymph flow, must disturb the cells tending to circumscribe the bacilli. The patients I have treated have all been adults. They probably present instances of thoroughly vaccinated individuals, in whom, however, during one of the fluctuations in immunity induced by intercurrent infection, fatigue, poor surroundings, etc., bacilli have again entered the circulation, and caused a local lesion.

Evidence that bacilli can live for years in calcareous lymph nodes and in old foci in bones is convincing. Bacilli obtained from old healed lesions inoculated in guinea pigs have multiplied and produced their characteristic lesions. Koenig<sup>7</sup> has reported the following pertinent case. A woman had had a tuberculosis of the foot when ten years old. The lesion healed and she used the foot for sixty years. When seventy years old, after a blow, it became painful and rapidly progressive tuberculosis made amputation necessary. An old tuberculous cheesy focus was found in the tibia with a sequestrum.

In the result of blood cultures reported by Saenz<sup>11</sup>, the positive cultures were, as we have said, mostly obtained in children during the early stage of dissemination but others were found in patients that showed renewed activity in an old lesion. That bacilli from time to time invade the body from without also seems evident. In one of the instances I have reported, the woman had been nursing a husband who had died of pulmonary tuberculosis.

Repeated small traumatisms, anatomical peculiarity, altered physiological conditions from overuse may have contributed to the deposit and local growth of bacilli. In a patient in whom the leg had been amputated for tuber-

culosis of the knee, a lesion of the chest wall had healed after excision. In two months the patient returned with a second tuberculous abscess on the opposite side of the chest. The abscess had formed directly beneath the heavy canvas strap used to hold the artificial leg in place. In a second instance I had amputated above the knee for a curious form of elephantiasis due to tuberculous infection of the lymphatic vessels. After amputation the patient used an artificial leg. When first using it he walked with a cane bearing much weight on his hand. In about a month signs appeared of tuberculosis in one of the metacarpal bones of this hand. Three of the patients I have treated were over fifty-five. Little has been written on behavior of extrapulmonary tuberculosis in old people since the paper by Sir James Paget on *Senile Scrofula*<sup>2</sup> in 1875. The disease is characterized by a tendency to run an indolent course with little reaction and little tendency to heal. However wide excision induced sound and permanent healing in two of the three.

Today it is not sufficient to say that tuberculosis is a general disease and that one must search for foci. There must be some attempt to appreciate the stage in the course of the disease and to realize that treatment is directed toward helping the invaded body to shut in and destroy the infecting bacilli. The surgeon never cures infection, he does something at a certain stage of infection which helps the body in an astonishing way to overcome infection and to shut in and render harmless local foci of infection. But the time must be seized when the infection is localized and the immunity high. Results are accomplished rapidly and deformity avoided by mechanical measures, whereas the natural cure might take years and results in crippling deformity. There has been, and there continues to be, a mortality of over twenty per cent, that is to say, in a very considerable number, the virulence of the implanted bacilli and the resistance of the individual and the frequency of the inoculation are such that the disease slowly progresses in spite of all the measures at our disposal.

I have purposely not used the terms primary, secondary and tertiary but they are useful terms and have come to stay.



They indicate, if understood properly, certain phases shown clinically by morbid physiology and shown anatomically by a characteristic morbid anatomy.

The first phase with limited distribution and characterized by a special anatomical picture and little allergy, can be advantageously treated by protection from contaminating contacts, by rest, by sunshine and proper nourishment.

The second phase with wide dissemination, high hypersensitiveness to the tuberculo-toxins, exudative inflammation and caseation can be advantageously treated toward the end of the phase when the foci are in bones and joints by immobilization and when the focus is in other accessible structures, by excision and the general measures referred to above.

The tertiary phase, with local progressive destructive lesions and with at first, high immunity, can be treated advantageously by excision and if near a joint by immobilization by fusion combined with the general measures.

The rule that aspiration is suitable treatment for a tertiary tuberculous abscess is not tenable provided the walls of the abscess and the feeding focus can be removed.

Rules of drainage applicable to foci of pyogenic infection are not suitable for tuberculous foci and tuberculous foci with secondary infection. Excision is the treatment.

The surgeon does not eradicate tuberculosis. He helps the tuberculous patient during a certain phase of the infection to get well, often in a most satisfactory and astonishing manner.



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